

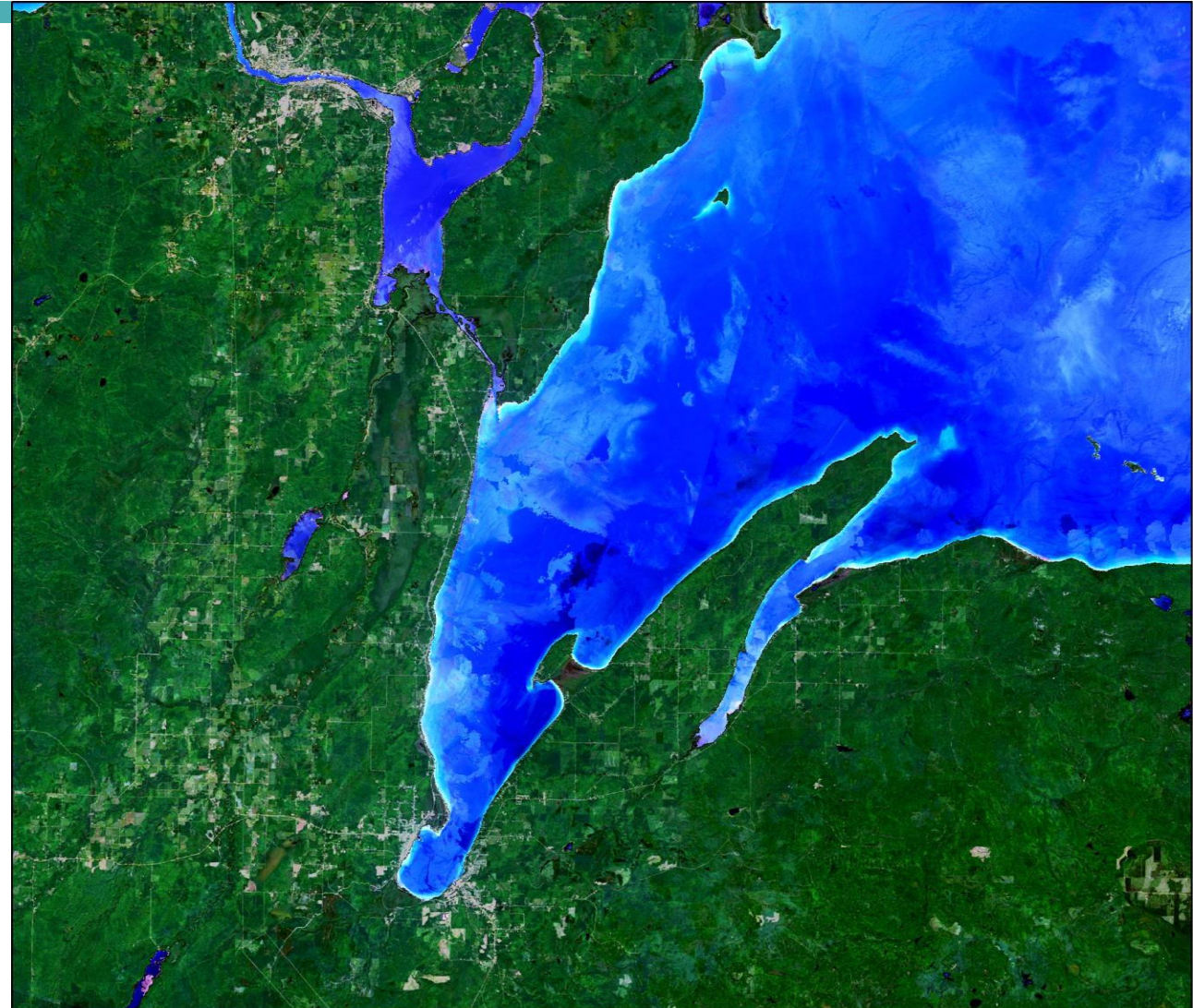


# KEWEENAW BAY

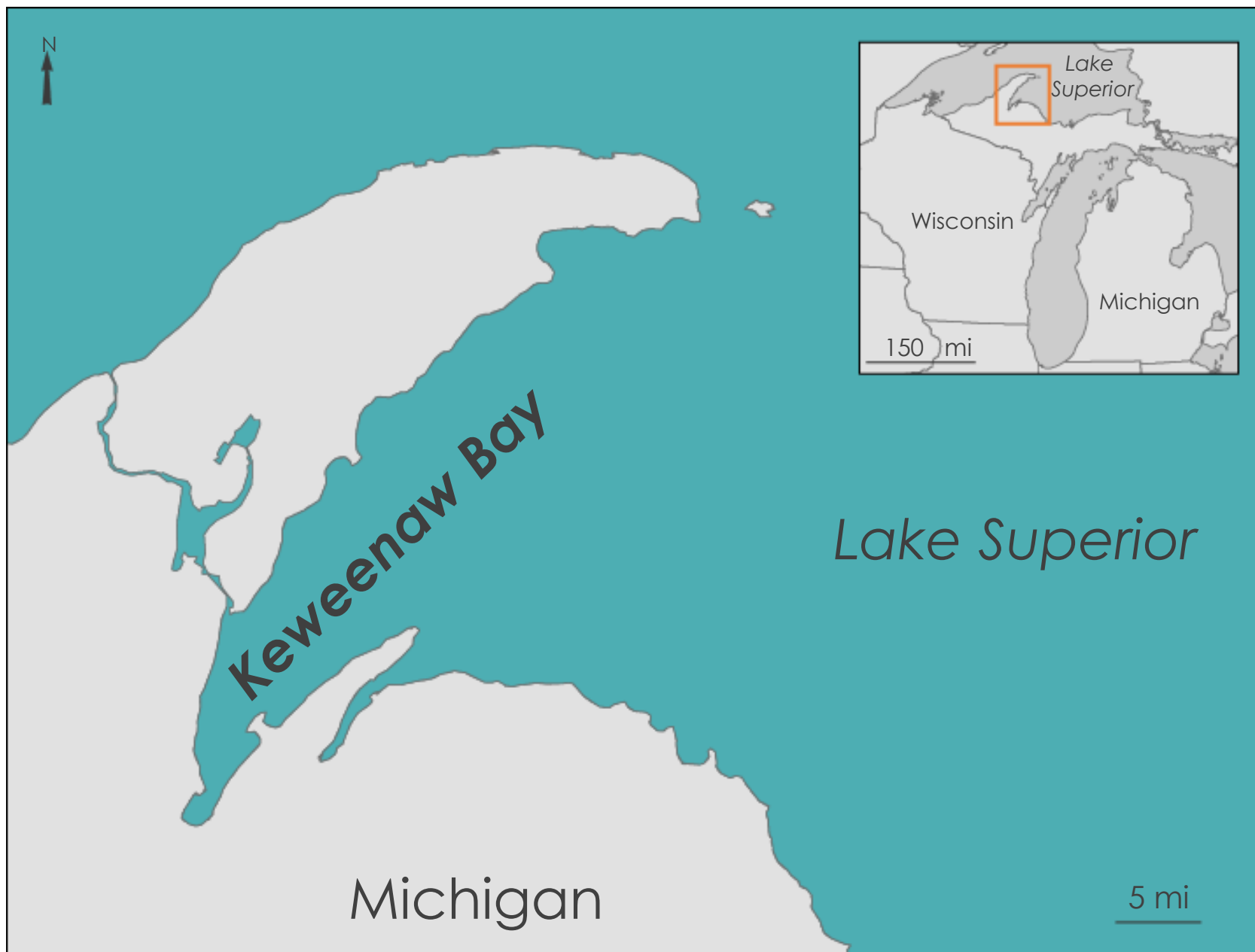
## Water Resources

Turbidity Data Decision Support for  
Shoreline Assessment and Management in  
Lake Superior's Keweenaw Bay

Khaim Syed-Raza  
Lisa Siewert  
Nora Whitelaw-McDonald  
Sofia Vakhutinsky



# STUDY AREA





# Project Partner and Collaborator

- ▶ **Keweenaw Bay Indian Community Natural Resources Department**

- ▶ Oversee the L'Anse Reservation's shoreline and water quality
- ▶ Monitor metallic mining and exploration activity in the Lake Superior basin
- ▶ Protect wildlife and manage wetlands

- ▶ **Environmental Protection Agency (EPA) Office of Community Revitalization**

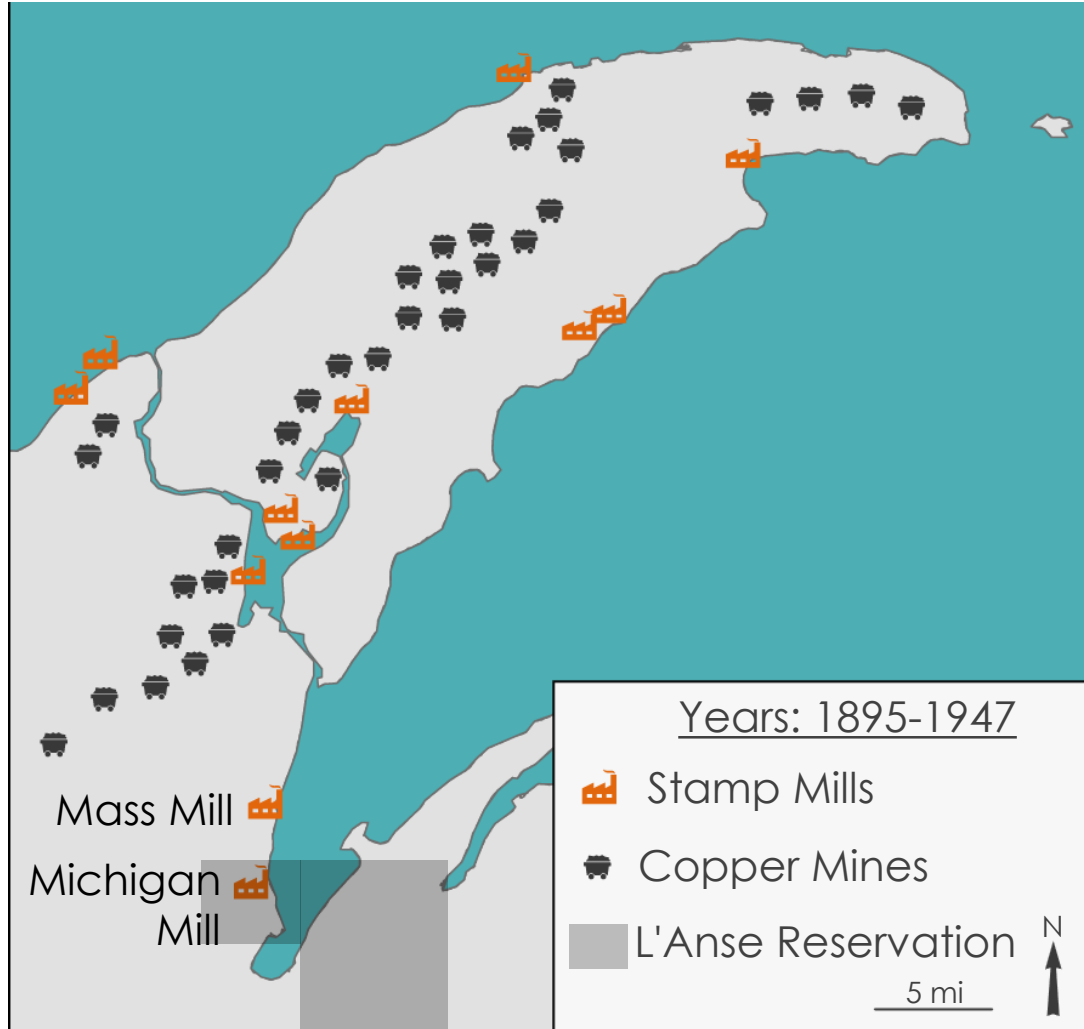


Image Credit: jdadelmund



# COMMUNITY CONCERNS – STAMP SANDS

## "Copper Country"



copper-rich  
rocks crushed at  
stamp mills to  
extract copper



**"stamp sands"**  
fine gravels laden  
with heavy  
metals

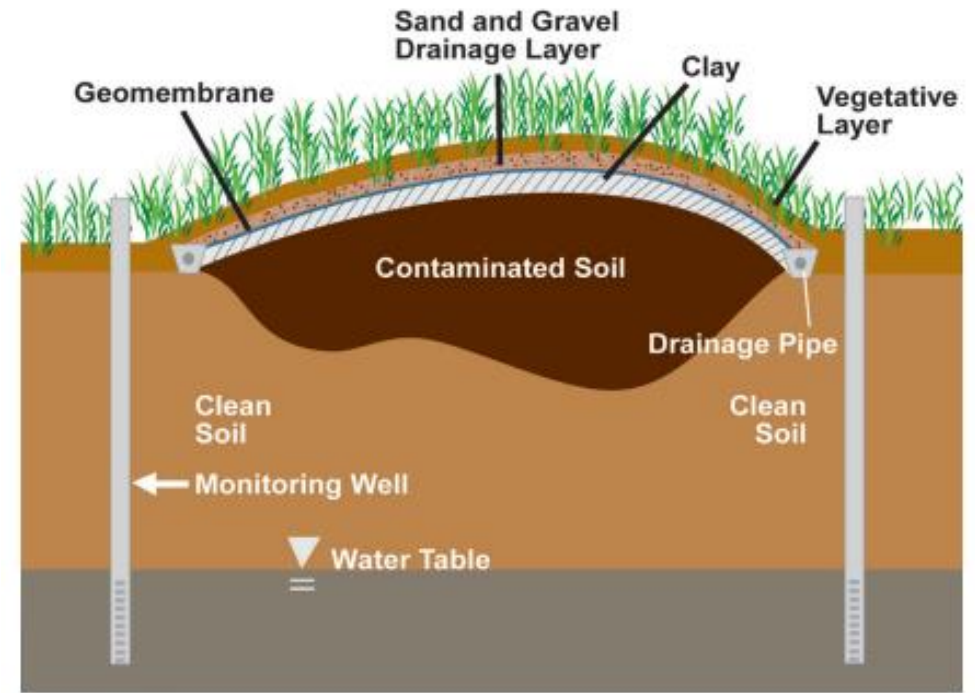
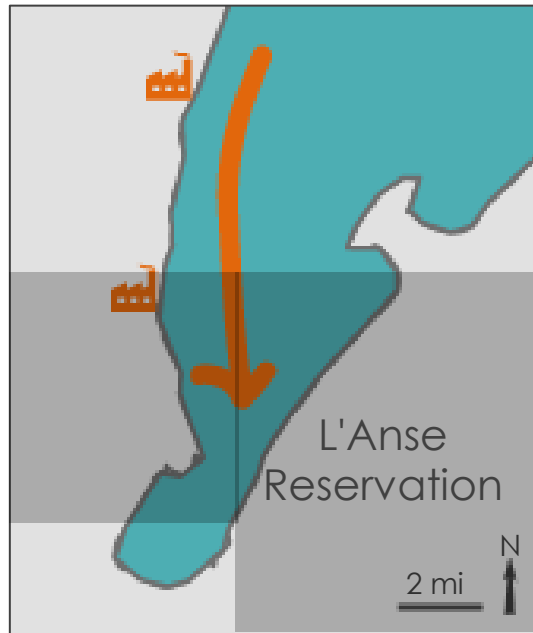


# COMMUNITY CONCERNS – STAMP SANDS



Michigan and Mass Mills (1901-1918) discarded ~6 billion pounds of stamp sands north of L'Anse reservation

Keweenaw Current transports sediments north to south



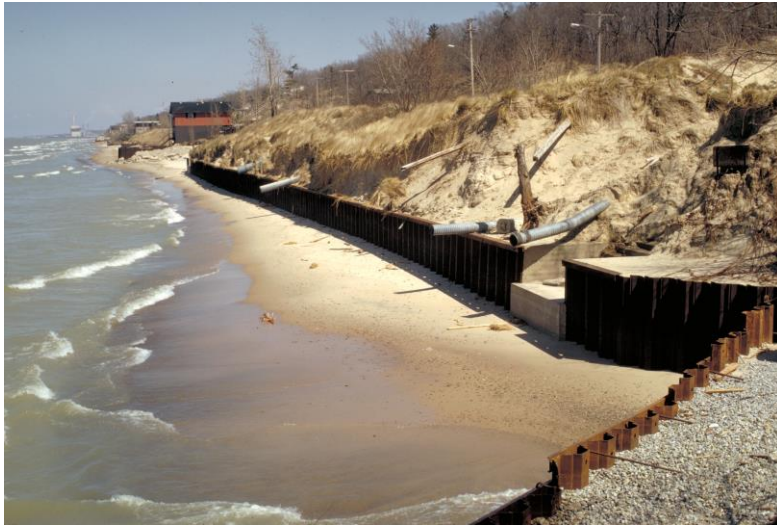
KBIC installed a cap of sandy loam soil on top of stamp sand deposits





# COMMUNITY CONCERNS

## Erosion



Redistribution of  
stamp sands



Impacts to coastal  
highways and  
infrastructure



Loss of public  
beaches and  
shoreline



# OBJECTIVES



**Create** a seasonal turbidity analysis



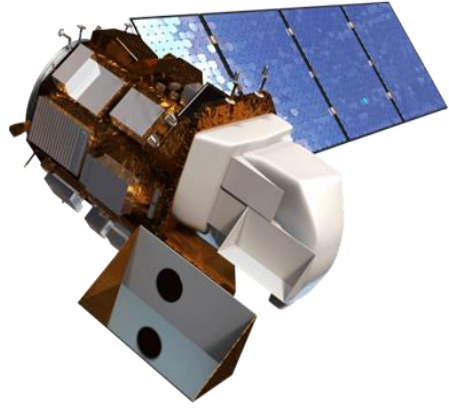
**Understand** the sediment redistribution patterns in the bay during snowmelt, rainy, and dry seasons



**Provide** insight to our partners on coastal sediment dynamics



# EARTH OBSERVATIONS



**Landsat 8 Operational  
Land Imager**



**Sentinel-2  
Multispectral Instrument**

2013

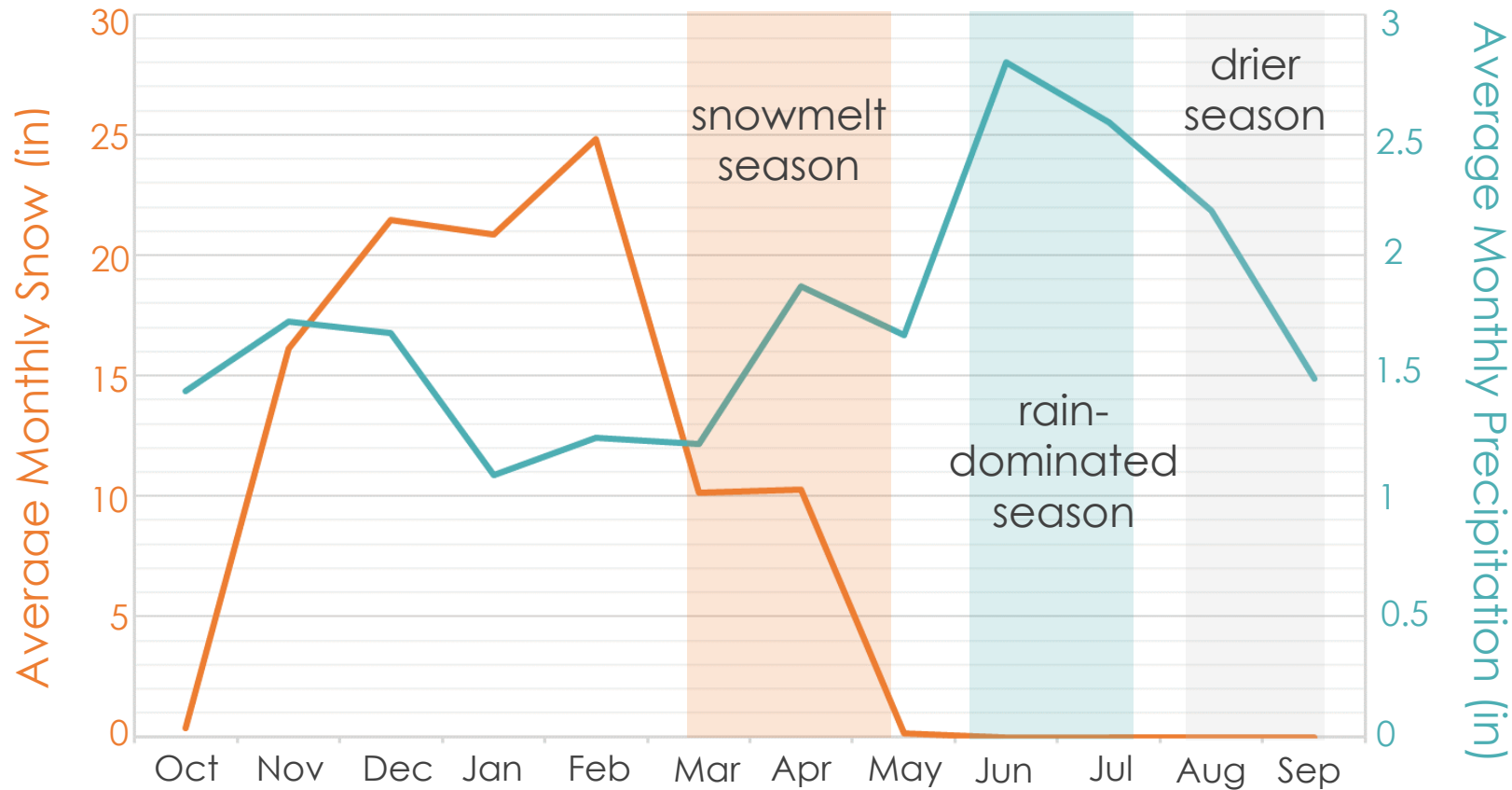
2015

2022





# METHODS



Determine peak snowmelt & precipitation seasons from local NWS records (Baraga-7 Station)



# METHODS

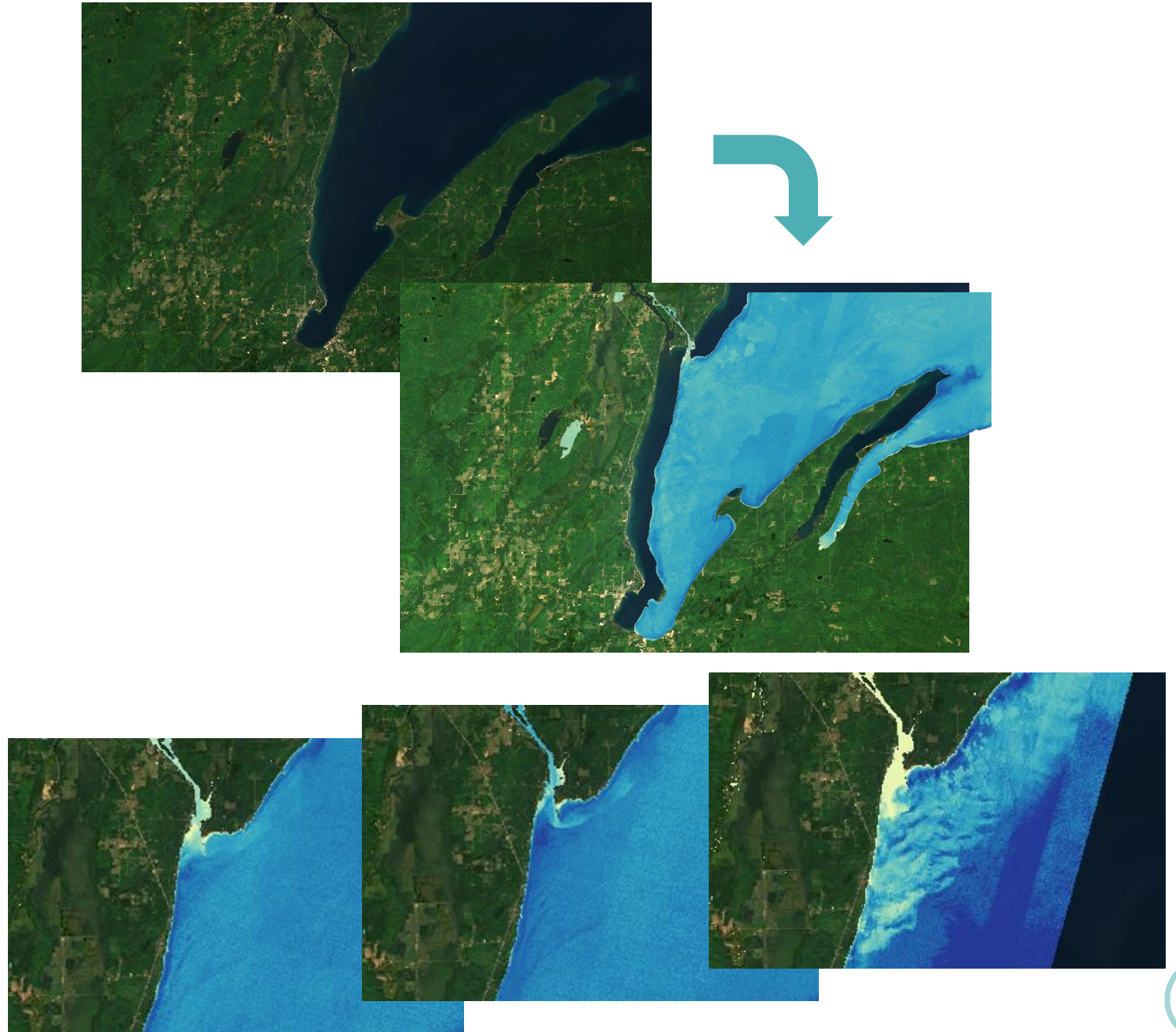
Acquire satellite imagery in GEE



Process images to isolate water and visualize turbidity



Compare spatial variations in turbidity between seasons



# RESULTS – MEDIAN TURBIDITY



**Snowmelt  
Season**  
(Early-Mid Spring)  
*Median Values*



**Rain-Dominated  
Season**  
(Summer)  
*Median Values*



**Drier Season**  
(Late Summer-  
Early Fall)  
*Median Values*





# RESULTS – MAXIMUM TURBIDITY



**Snowmelt  
Season**  
(Early-Mid Spring)  
*Maximum Values*



**Rain-Dominated  
Season**  
(Summer)  
*90th Percentile*



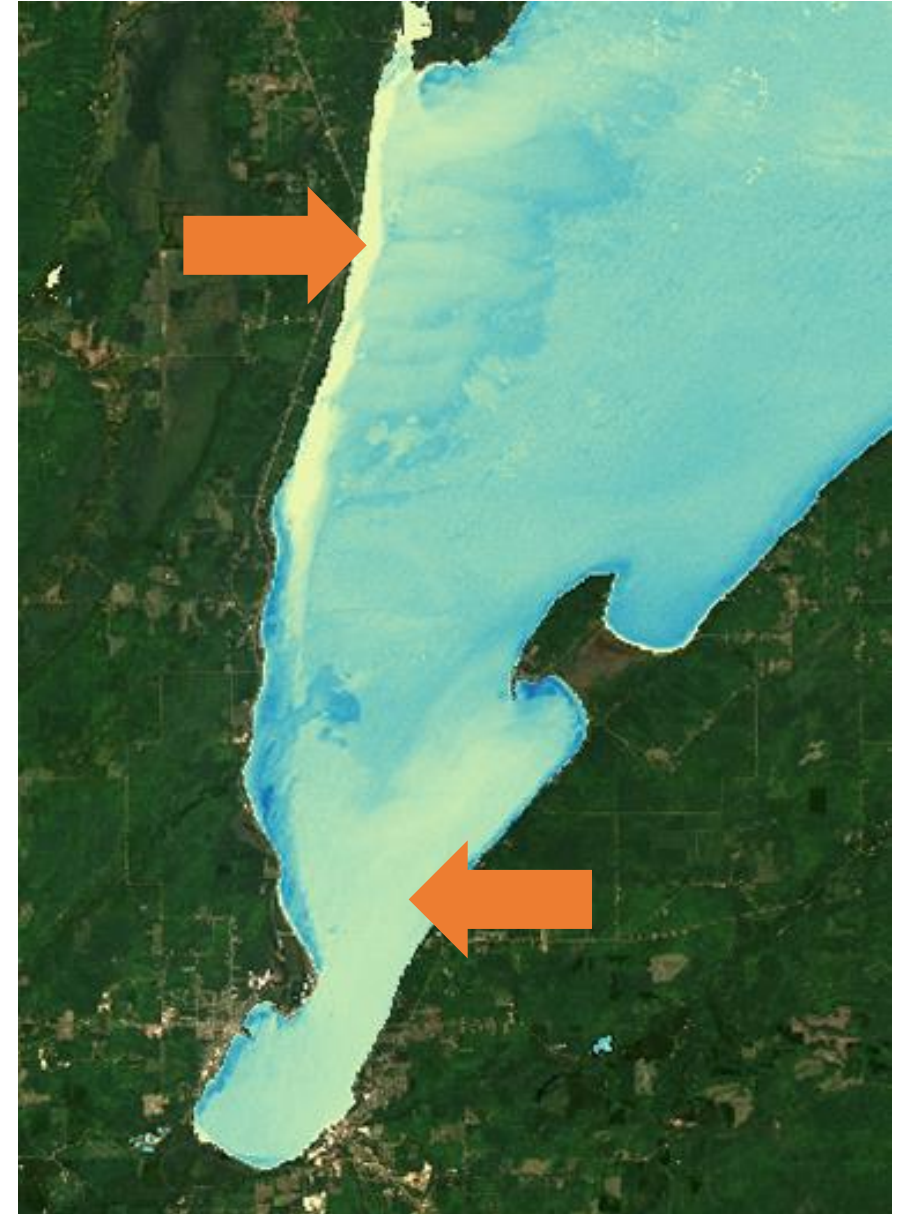
**Drier Season**  
(late Summer-  
Early Fall)  
*Maximum Values*



# CONCLUSIONS

## Rainy season

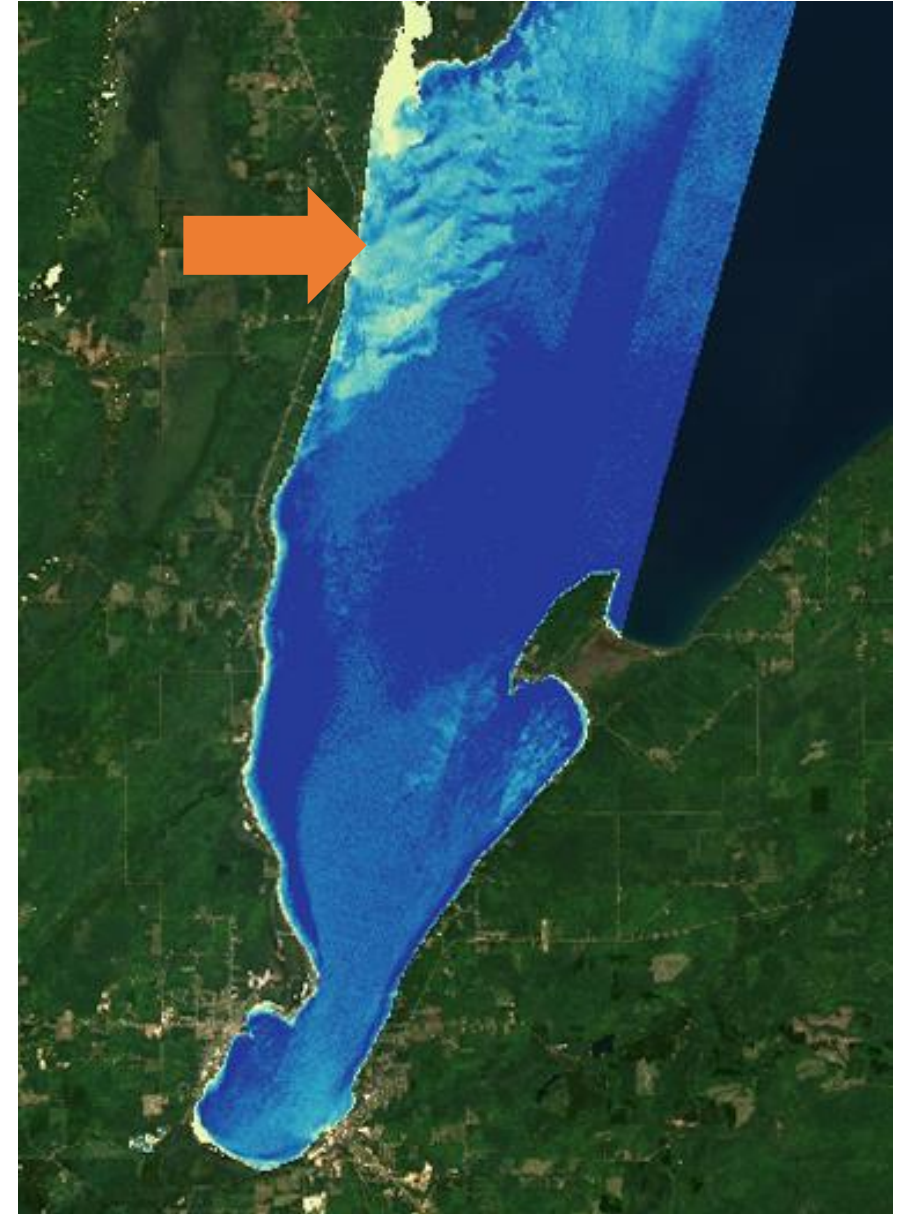
highest relative turbidity  
observed, but spatial patterns  
of coastal erosion were unclear



# CONCLUSIONS

## Snowmelt season

high turbidity at river mouth, low turbidity in lower bay, suggests river doesn't always contribute to turbidity





# CONCLUSIONS

## Drier season (control)

scattered turbidity might indicate  
occurrence of erosion not driven  
by rain/snowmelt



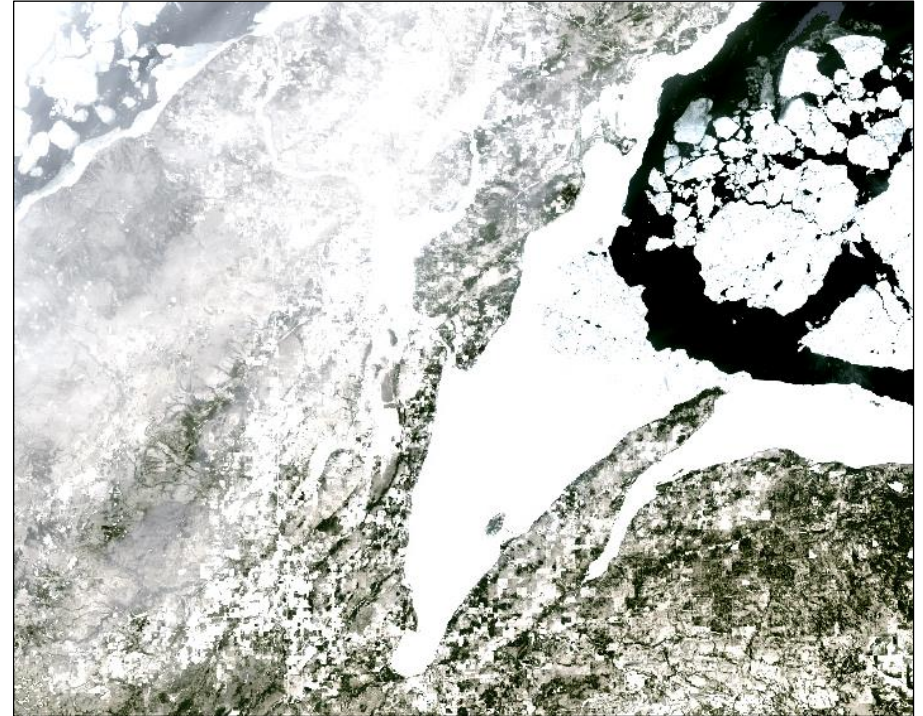
# ERRORS & UNCERTAINTIES

▶ Limited satellite imagery 

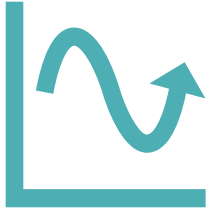
▶ Persistent cloud cover 

▶ Short snowmelt season 

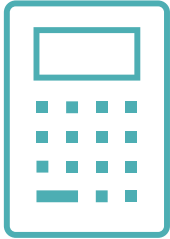
▶ Lake ice obscuring turbid water 



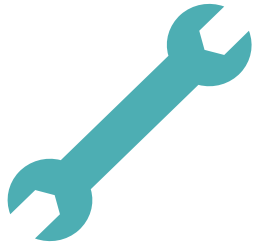
# FUTURE WORK



**Record** the direction of sediment transportation



**Calculate** volume of eroded sediment with seasonal variation



**Address** uncertainties in data processing techniques





# ACKNOWLEDGEMENTS

## **Partners:**

Keweenaw Bay Indian Community (KBIC)  
Dione Price  
Evelyn Ravindran  
Erin Johnston  
Luis Verissimo

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Environmental Protection Agency (EPA)  
Abby Hall  
Sarah Gruza

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Dr. Kenton Ross (Langley Research Center)  
Lauren Childs-Gleason (Langley Research Center)

## **NASA DEVELOP:**

Olivia Landry (NASA DEVELOP LaRC Fellow)  
Cecil Byles (NASA DEVELOP LaRC Senior Fellow)

*\*This material contains modified Copernicus Sentinel data (2015-2022), processed by ESA.*